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Use of radio-telemetry to reduce bias in nest searching

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ABSTRACT. We used traditional searching, as well as radio-telemetry, to find 125 Wood Thrush (*Hylocichla mustelina*) nests during 1994–1996 at the Piedmont National Wildlife Refuge in Georgia, USA. We compared daily nest survival rates for 66 nests of radio-marked birds with 59 nests of birds found through systematic searching. By using radio-telemetry, we found Wood Thrush nests in higher elevation pine habitats, in addition to the more usual hardwood forests with moist soils. We found nests of radio-marked birds farther from streams than nests found by systematic searching. Thirty-two percent of radio-marked birds' nests were found at the tops of slopes, compared to 15% of the nests found by traditional searching. In addition, radio-marked birds generally moved up-slope for re-nesting attempts. Although the distribution of nests found with telemetry and searching varied, daily nest survival did not vary between the two groups. Radio-telemetry provided new information about Wood Thrush nesting habitats. We believe radio-telemetry can be a valuable addition to traditional searching techniques; it has the potential to provide a sample of nests free from a priori habitat biases.

SINOPSIS. **Utilización de radiotransmisores para reducir el sesgo en la búsqueda de nidos**
Utilizamos la búsqueda tradicional de nidos y el de aves equipadas con radiotransmisores para localizar 125 nidos de *Hylocichla mustelina.* El estudio se llevó a cabo en Piedmont National Wildlife Refuge en Georgia. Comparamos la tasa de supervivencia diaria de 66 nidos encontrados con radios y de 59 de la forma tradicional. La radiotelemetría nos permitió encontrar nidos del ave en zonas elevadas con arboles de pino, en vez del lugar más usual como lo son bosques de maderas duras con suelos húmedos. Con los transmisores localizamos nidos a mayor distancia de cuerpos de agua, que con el método tradicional. Un 32% de las aves con transmisores, fueron encontradas anidando al tope de pendientes, comparado con un 15% usando el método tradicional. También encontramos que las aves con los transmisores reutilizaban dichas pendientes para reanidar. Aunque la distribución de nidos encontradas usando ambos métodos varió entre estos, no se encontró diferencia en la supervivencia diaria. La radiotelemetría permitió obtener información nueva sobre el hábitat de anidamiento de la especie estudiada. Creemos que la radiotelemetría puede ser de gran valor para la búsqueda de nidos y tiene el potencial de proveer información que podría traer como consecuencia sesgo en un estudio.

Key words: bias, *Hylocichla mustelina*, nest monitoring, nest survival, radio-telemetry, Wood Thrush

Avian ecologists often use samples of nests to compare productivity among populations. Wilson et al. (1998) cautioned against the use of artificial nests for estimating rates of predation or parasitism because of associated biases. We suggest that samples of active nests may also be biased.

Nichols et al. (1986) demonstrated that trained observers could not detect all nests in a colony of White-winged Doves (*Zenaida asiatica asiatica*). Therefore, it is reasonable to expect that detection probabilities for non-colonial songbirds may vary even more significantly with respect to habitat and nest height. Field workers may also have inherent biases in where they search for nests, regardless of instructions to search systematically. These potential problems can cause the sample of nests found to be non-representative of the population of nests.

Ornithologists often rely on nest-finding techniques—search images, area-restricted searches, micropatch partitioning, and directed searches—that are similar to techniques used by some natural nest predators. Whelan et al. (2003) noted that predators' search behavior

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may lead to biases in detection of natural prey. Therefore, it is possible that samples of active nests, discovered by research biologists, may also be the easiest for predators to detect. In fact, Bromley et al. (1995) reported that during years of low nest survival, Canada Geese (*Branta canadensis*) and White-fronted Geese (*Anser albifrons*) were more easily detected on surveys than in years of high nest survival; in addition, failed Canada Goose nests were more easily detected than failed White-fronted Goose nests because of differences in nesting habitat.

Bibby et al. (1992) noted that distribution data obtained by radio-telemetry are less biased by the observer than similar data collected by survey methods. While radio-telemetry is usually used to determine locations of individual animals in a non-biased fashion (Kenward 2001), we believe that radio-telemetry has the potential to reduce potential bias in studies of nesting birds. For example, Wood Thrushes (*Hylocichla mustelina*) are traditionally classified as nesting in hardwood forests with moist soil (Roth et al. 1996). Initial observations at our research site indicated that Wood Thrushes were also found in drier, up-slope areas that might have been missed with searching that targeted the traditional moist-soil (bottom of slope) habitats. Our objectives were to use radio-telemetry to find a subsample of Wood Thrush nests, and compare daily nest survival and location of nests found with the two methods.

METHODS

We conducted this study between April and September during 1994–1996 at the Piedmont National Wildlife Refuge (PNWR) in the southern Piedmont of Georgia, U.S.A. The 14,146-ha refuge is principally mature pine/hardwood forest dominated by loblolly pine (*Pinus taeda*), oaks (*Quercus* spp.) and hickories (*Carya* spp.).

We used two methods to search for nests. First, we visually searched all habitat types systematically for Wood Thrush nests from early April until mid-August. We coordinated our nest searching efforts with transect surveys conducted concurrently on the study plots (Powell et al. 2000), and we targeted some nest searching in apparent territories of singing males.

We also found Wood Thrush nests by following radio-marked females to their nests. Females were radio-marked during systematic mist netting along transects in our study sites, as well as target-netting that we conducted in known territories (Lang et al. 2002). We used non-gel super glue to temporarily attach a 1.6-g radio transmitter to the back of each female; our attachment methods were similar to those described by Kenward (2001). The adhesive usually failed after 1–2 wks, and we recovered the radio to mark other females until battery failure occurred (battery life was about 45 d). We used hand-held antennas to locate the female and determine a nest location. After locating a nest, we recorded the height of the nest and nest tree using a clinometer, as well as distance to the nearest stream. We also recorded the position of the nest on the slope (top, middle, or bottom third).

We used program SURVIV (White 1983) to estimate daily nest survival rates for the nests in our sample. Lang (1998) reported no year-to-year variation in daily nest survival from the same sample, so we pooled all nests across 1994–1996. We used chi-square, t-test, ANOVA (SAS 2000), and 95% confidence intervals (Steidl et al. 1997) to determine if nests located with radio-telemetry were in different habitat than nests located by visual methods.

RESULTS

We found 125 active Wood Thrush nests at PNWR (31 in 1994, 44 in 1995, and 50 in 1996). We located 66 of 125 (53%) of our Wood Thrush nests using radio-telemetry; the best chances of finding the female on the nest occurred in early morning or mid-afternoon. During 1995, we estimated that our crew averaged 16 h of searching per nest using systematic methods. Because we attached radios during concurrent mist-netting efforts for our study (Powell et al. 2000), finding nests of radio-marked birds only required a maximum of one to two hours of telemetry work to find the female on the nest.

Nests of radio-marked females were farther from streams ($\bar{x}_{radio}$ = 111.8 m, 95% CI 85.4–138.1; $\bar{x}_{systematic}$ = 64.4 m, 95% CI 41.6–87.1; $t_{123} = -2.69$, $P = 0.008$) than nests found by systematic searching. Nest heights were not different ($\bar{x}_{radio}$ = 6.1 m, 95% CI 5.1–7.1; $\bar{x}_{systematic}$ = 5.7 m, 95% CI 5.1–6.2; $t_{123} = -0.74$; $P =$

Table 1. Locations and daily nest survival ($\hat{S}$) of 125 active Wood Thrush nests among three slope categories and two nest searching methods at Piedmont National Wildlife Refuge, central Georgia, during 1994–96.

Slope position	All nests				Systematic searching		Radio telemetry		First nest attempts[a]		Re-nesting attempts[a]	
	N	%	$\hat{S}$ (SE)	95% CI	*N*	%	*N*	%	*N*	%	*N*	%
Top	30	24.0	0.9465 (0.0089)	0.9269–0.9707	9	15.3	21	31.8	4	19.0	15	36.6
Middle	40	32.0	0.9542 (0.0091)	0.9363–0.9721	19	32.2	21	31.8	5	23.8	15	36.6
Bottom	55	44.0	0.9488 (0.0112)	0.9290–0.9640	31	52.5	24	36.4	12	57.2	11	26.8

[a] Radio-marked females only.

0.46). But we were able to document nest heights of up to 33 m with radio telemetry; the highest nest found with systematic searching was 12 m. Twenty-one of 66 (32%) nests of radio-marked females were found on the top of the slope (thus, farther from streams), compared to only nine of 59 (15%) nests found by systematic searching (χ^2_2 = 5.42, P = 0.07). Re-nesting attempts by radio-marked birds tended to be found more frequently at the tops of slopes than first attempts (χ^2_2 = 5.54, P = 0.06; Table 1).

Nests found by telemetry had an apparent success rate of 31.8% (21 of 66; 95% CI 26.1–37.6), while nests found by searching had a success rate of 30.9% (17 of 55; 95% CI 24.7–37.1; χ^2_1 = 0.01, P = 0.92). The fate of four nests could not be determined. Daily nest survival ($\hat{S}$) of nests found by telemetry ($\hat{S}$ = 0.9493, SE = 0.0075; 95% CI 0.9346–0.9641) did not differ from nests found by systematic searching ($\hat{S}$ = 0.9467, SE = 0.0087; 95% CI 0.9297–0.9637). Daily nest survival was also not influenced by the nests' position on the slope (Table 1).

DISCUSSION

Using mostly traditional, visual nest searching methods, Wood Thrushes have been classified as shrub-nesting species, usually found in hardwood forests in areas with moist soil (Roth et al. 1996). We found radio-marked female Wood Thrushes farther from streams (and moist soil) and higher on slopes than unmarked females, and radio-marked females' nests were somewhat higher. Just as radio-telemetry accounts for unknown mortalities of birds (Powell et al. 2000), it can also provide new information on nesting habitat, such as the use of higher-elevation pine habitats in our study.

We systematically searched for nests in all habitat types of our study plots. However, we tended to concentrate on a priori defined habitats and areas reported to be prime nesting areas for Wood Thrushes (Roth et al. 1996). At our study area, nest success did not vary among local habitat types, but our nesting study could have been biased without radio-telemetry. In addition to avoiding potential biases among local habitats, radio-telemetry was useful in finding nests that were not likely to be detected visually. As an example, one of our radio-marked birds nested 33 m from the ground, a nest impossible to find with normal searching methods. Although we were not able to monitor this nest, we did gain information on Wood Thrush nesting habitat. The level of potential bias from traditional nest searching methods will vary among studies, but it is possible to use mark-recapture methodology (Nichols et al. 1986) to quantify the effectiveness of traditional searching methods.

Monitoring radio-marked females also allows the collection of renesting data that could not be accomplished without telemetry. McAuley et al. (1990) and Stober and Krementz (2000) were able to document for the first time multiple brooding by American Woodcocks (*Scolopax minor*) and Bachman's Sparrows (*Aimophila aestivalis*). Lang et al. (2002) used telemetry to document up to five nesting attempts by Wood Thrushes in our study. For birds that multi-brood, telemetry is the most effective method that allows biologists to document between-nest movements and estimate associated demographic parameters, such as annual productivity.

Radio-marking animals can potentially affect survival or behavior (Withey et al. 2001), and biologists have shown adverse effects of transmitters on courtship behavior, reproductive success, and nesting behavior of some bird species (Neudorf and Pitcher 1997). Although our own research indicated that radio-tags did not affect apparent survival and general behavior of Wood Thrushes (Powell et al. 1998), we urge investigators to consider the potential effects of radio telemetry on the nesting behavior of birds. If transmitters were to negatively affect nesting behavior, radio-telemetry would not provide an unbiased sample of nests.

Radio-marking birds for nesting studies has other benefits. Our nest searching effort was cut in half, as we estimated 16 h for each nest found with systematic searching. To find nests with radio-telemetry, the same person-hours would instead be spent on two or three 3-h mist-netting sessions (nets placed systematically in all habitats), with 1–2 h of telemetry to locate the female on the nest. Radio-telemetry is expensive, but can be cost effective by cutting labor costs; we re-used the same radio for at least four nest finding missions. In addition, the costs of telemetry could be offset by additional data gathered during mist netting sessions, such as species richness or mark-recapture data. Therefore, we suggest that biologists use radio-telemetry as an efficient nest searching technique, which may result in an unbiased sample of nests.

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